A report prepared for the National Park Service Klamath Network Inventory and Monitoring Program

Level 1 Baseline Water Quality Report for the Klamath Network: Lava Beds National Monument, Lassen Volcanic National Park and Oregon Caves National Monument – 2005.

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Contents

Figures

Executive Summary

In the summer and fall of 2005, the USGS, in cooperation with the National Park Service, collected and analyzed water samples from Lava Beds National Monument, Lassen Volcanic National Park, and Oregon Caves National Monument. Water quality data are provided for select water bodies located in these park units. The inventory was part of a nationwide program developed by the National Park Service to obtain baseline water quality information for the significant water resources located in national parks and monuments throughout the United States. This water quality monitoring effort supplements previous work documented in Horizon Reports, which were compiled by the National Park Service Water Resources Division. Data were collected for National Park Service (NPS) baseline level 1 parameters: alkalinity, dissolved oxygen, pH, specific conductance and temperature. Additional parameters measured for select water bodies include chloride, nitrate and total and fecal coliform. These data describe the current water quality at selected sites and provide baseline water quality information needed to design programs to monitor future trends.

At Lava Beds National Monument (LABE) water and ice samples were collected from many caves. Concentrations of alkalinity expressed as $CaCO_3$ and HCO_3^- for melted ice and water samples collected at LABE ranged from a low of not detected (ND) to a high of 180 mg/L for $CaCO_3$ and 220 mg/L for HCO_3^-. Generally, alkalinity was higher in October than in May. Specific conductance measurements ranged from a low of ND to a high of 589 μmhos/cm, and measurements were generally higher in October than in May. pH measurements ranged from 5.26 to 9. Almost all samples were within the range of 6-9, considered acceptable for most aquatic life. Average pH was slightly lower in October than May. Dissolved oxygen concentrations were only available for a limited number of sites in October and ranged from a low of 3.33 mg/L (below the 5 mg/L minimum for cold water aquatic life) for a water sample collected at Duffy's Well to a high of 12.36 mg/L for a water sample collected at Merrill Ice Cave.

At Lassen Volcanic National Park (LAVO), concentrations of alkalinity expressed as $CaCO_3$ and HCO_3^- in water samples ranged from a low of not detected (ND) to a high of 66 mg/L for $CaCO_3$ and 81 mg/L for HCO_3^-. Alkalinity was generally higher in August than in June or July. Specific conductance measurements ranged from a low of ND to a high of 97 μmhos/cm. Specific conductance was slightly higher in July than in August at three of the five sites sampled in both months. pH measurements ranged from 5.88 to 9.62. pH was generally higher in August than in June or July. Dissolved oxygen measurements were all above 5 mg/L, and ranged from 6.1 mg/L to12.34 mg/L. Dissolved oxygen was generally higher in June and July than in August. Fecal and total coliform counts were generally low. Fecal coliform colonies ranged from <2 colonies to 13 colonies per 100 ml of water, which is within the safe limits for recreational use. Total coliform colonies ranged from a low of <2 colonies to 140 colonies per 100 ml. Total coliform counts were higher in August than June at all three sites sampled both months and higher in July than August in three of the four sites sampled both months.

At Oregon Caves National Monument (ORCA), alkalinity expressed as $CaCO_3$ ranged from 30 mg/L to 120 mg/L. Average $CaCO_3$ was equal to or greater in samples taken in October than May at all seven sites measured both months. HCO_3^-

measurements were only available in October and ranged from 48 mg/L to 120 mg/L. Specific conductance measurements were only available in May and ranged from 34 μmhos/cm to 220 μmhos/cm. pH measurements ranged from 7.3 to 8.1. Average pH was generally higher in samples taken in October than in May. Dissolved oxygen concentrations ranged from 10.48 mg/L to 11.87 mg/L. Average dissolved oxygen concentrations were lower in October than May. Chloride concentrations ranged from 0.61 mg/L to 5 mg/L, and were higher in October than May. Nitrate concentrations ranged from not detected (ND) to 0.11 mg/L. Fecal coliform counts were all low, and ranged from <2 to 8 colonies per 100 ml of water. Total coliform ranged from <2 to 27 colonies per 100 ml.

Introduction

In 1992, the National Park Service (NPS) established a nationwide Level 1 Water Quality Inventory and Monitoring program to obtain baseline water quality information and to assess possible water quality issues for key water resources in national park units throughout the United States. Key water resources are those that are essential to the cultural, historical, or natural resource management themes of the unit or that provide habitats for threatened or endangered species. The basic chemical characteristics and observed water quality problems of the water resources are described by analyzing selected water quality parameters.

The Klamath Network (KLMN) is one of 32 National Park Service networks created to monitor and manage the long-term ecosystem health of the nation's parks. The park units of the KLMN are Crater Lake National Park (CRLA), Lassen Volcanic National Park (LAVO), Lava Beds National Monument (LABE), Oregon Caves National Monument (ORCA), Redwood National and State Parks (REDW) and Whiskeytown National Recreation Area (WHIS) (Figure 1). CRLA, WHIS and REDW have a baseline of water quality information available. Until recently, LAVO, LABE and ORCA have had very limited water quality data collection. In 2005 the USGS, in cooperation with the National Park Service, collected and analyzed water samples from LABE, LAVO and ORCA. The purpose of the present effort is to expand the database of parks' water quality information previously compiled in Horizon Reports, which can be downloaded from the National Park Service's Water Resource Division web site at: http://www.nature.nps.gov/water/horizon.htm.

LAVO, LABE and ORCA represent a wide range of conditions, from the Siskiyou Mountains and Klamath Geologic Province in the north to the Cascade Range Geologic Province to the south. Vegetation varies from desert sage to temperate coniferous forests. The climate varies from semi-arid, warm and dry summers to cold and wet winters. Precipitation at the sites varies from about 15 inches to over 40 inches per year, and occurs mainly from October through May.

Lassen Volcanic National Park is a 106,372-acre NPS unit located in the southern range of the Cascades in northeastern California. The landscape is dominated by volcanic processes and includes 277 permanent and ephemeral lakes. Portions of five drainage basins are located within the park boundaries, and four of the drainage basins (nearly the entire park, ~99%) drain into the Sacramento River and eventually to the Pacific Ocean. All of the park's lakes and streams are considered important for wildlife and several receive high visitor recreational use. Several park lakes were formerly stocked with trout for recreational fishing and now contain self-propagating populations of trout. Mill Creek currently has no dams blocking anadromous fish and is one of very few stream courses remaining in California to have its biologic integrity preserved from its origin in northern California to the Sacramento River.

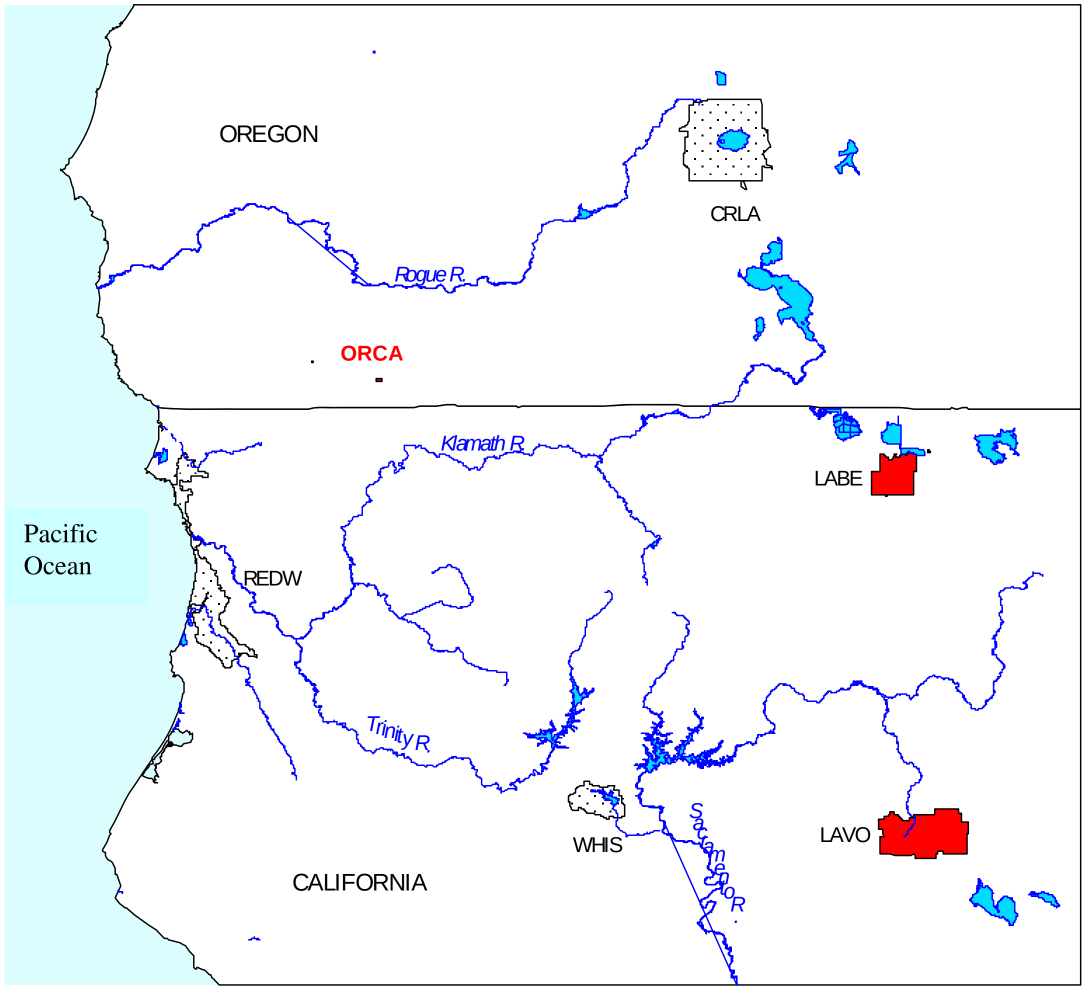

Figure 1. Klamath Network National Park units: LAVO (Lassen Volcanic National Park), LABE (Lava Beds National Monument), and ORCA (Oregon Caves National Monument) park units had a Baseline Level 1 inventory conducted in 2005.

Lava Beds National Monument is a 46,560-acre NPS unit located on the margin of the Cascade Range and the Great Basin Geologic Provinces in northeastern California. The monument contains a range of Great Basin vegetation communities, including ponderosa pine forests, mountain mahogany/juniper, and sagebrush/bunchgrass. Lava Beds National Monument currently has 502 lava tube caves documented within the monument with a total of 28.71 miles of passageway. No permanent or ephemeral lakes, streams or wetlands are found within the monument's boundary. A total of 28 caves within the monument are documented to contain ice and water. Many of these caves are important water sources for wildlife and historically have been used by an array of different people. Specific wildlife that benefit from these ice resources includes 14 species of bats and a number of different bird species. Two of the bat species that have been documented using the ice/water resources within the caves include the Townsend's big-eared bat (a species of concern) and Mexican free-tail bat (largest northern migratory colony of this species in the United States).

Oregon Caves National Monument is a 480-acre national park unit located in the Siskiyou/Klamath bioregion of southern Oregon. Although the monument is a small park unit, forest communities contained in the monument are a diverse representation of the larger bioregion, with old growth Douglas fir, white fir and oak forests covering the majority of the monument and providing diverse microhabitat opportunities for the monument's nearly 500 plants, 5,000 animal and 2,000 fungal species, which are among the highest number of fungal species catalogued per acre for any national park unit. Federally threatened and endangered species that reside or utilize the park include the northern spotted owl, bald eagle, and peregrine falcon. Federal and state species of concern found in the monument include the Del Norte salamander, Western toads, California mountain kingsnakes, goshawks, pileated woodpeckers, olive-sided and little willow flycatchers, red tree voles, ringtails, Western small-footed, long-eared, Yuma, and long-legged myotis bats, Pacific western big-eared bats, western gray squirrels, northern pygmy owls, and four mosses. All of the monument's cave pools, springs and streams are considered important water resources for wildlife.

Methods

The current water quality of the key water resources of Lava Beds National Monument, Lassen Volcanic National Park and Oregon Caves National Monument was determined by a combination of in-situ field measurements and lab analyses of water samples collected at several locations within each park unit. Water samples were collected according to standard USGS protocols described in USGS Techniques of Water-Resources Investigations Reports (Wilde *et al.* 1998). All water samples were stored on ice until delivered to a laboratory, within 24 hours of collection (or within eight hours for coliform analyses). Laboratory analyses of the water and ice samples collected at LABE were conducted at Basic Labs, Inc., Redding, CA and major ion analyses were conducted by Paul Schuster, USGS, Boulder, CO. Laboratory analyses of the water samples collected at LAVO were conducted at Basic Labs, Inc., Redding, CA. Laboratory analyses of the water samples collected at ORCA were analyzed at North Coast Labs, Inc., Arcata, CA. Both laboratories are certified by the State of California

Environment Laboratory Accreditation Program, operate under written Quality Assurance Plans, and follow standard operating procedures for testing each water quality parameter. Dissolved oxygen, pH, specific conductance and temperature were measured in the field with the use of a calibrated Yellow Springs Instrument 556 multi-parameter probe.

Samples were analyzed for the following properties or constituents: alkalinity, dissolved oxygen, fecal and total coliform, major ions, pH, specific conductance, temperature and discharge rates for streams. Concentrations of fecal bacteria were used to indicate whether or not animal or human fecal waste had affected the water quality of a water body. Samples were collected from water bodies in the following NPS units: LABE in May and October 2005, LAVO in June, July, August and September 2005, and ORCA in May and October 2005.

Results

Description and Significance of Water Quality Monitoring Parameters

The National Park service has established a set of core water quality monitoring parameters that should be collected in the monitoring component of the Vital Signs Program. The core parameters include temperature, specific conductance, pH and dissolved oxygen. Other parameters, such as total and fecal coliform or turbidity, may be useful for specific issues in a park unit. The following is a general description of the parameters of interest to Klamath Network park units, which were identified through the vital signs scoping process, and the significance of these parameters to specific resource concerns of the park units. More detailed information on the stressors on specific natural resource features in each park is contained in the Klamath Network Water Quality Report (Phase II) (Hoffman *et al.,* 2005).

pH

The pH of water is a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral and greater than 7 is more basic and less than 7 is more acidic). An acceptable pH for freshwater fish and benthic invertebrates is between 6 and 9 (Welch *et al.* 1998). pH also affects chemical weathering rates, especially in cave environments.

Alkalinity

Alkalinity is the sum total of components in water that tend to raise the pH of the water above a value of about 4.5; therefore it is a direct measure of the buffering capacity of water. Alkalinity is commonly expressed as milligrams per liter (mg/L) of carbonates ($CaCO_3$) and bicarbonates (HCO_3^-), the relative amounts of which are dependent on pH. Alkalinity has little or no direct effect on stream invertebrates and fish, and therefore there are no alkalinity water quality standards, although alkalinity directly affects pH, which does affect aquatic life (Welch *et al*. 1998). Alkalinity is of special concern in areas of karst topography, such as at ORCA, where dissolution of carbonate bedrock affects cave dynamics. Concentrations of carbonates can be used to monitor changes in cave environments.

Dissolved Oxygen

The amount of dissolved oxygen (DO) available in water is extremely important to the survival of aquatic species. The amount of DO in a stream is determined by the gas-absorbing capacity of the water, which is primarily dependent on temperature, turbulence and atmospheric pressure (Welch *et al.* 1998). Dissolved oxygen concentrations can be drastically decreased by organic pollution and elevated temperatures, but remain near 100% in unpolluted waters. The national criterion for ambient DO concentrations for the protection of cold water aquatic life has been established at a minimum of 5 mg/L (U. S. Environmental Protection Agency 1986).

Specific Conductance

The specific conductance is a measure of the ability of water to conduct electricity. The presence of charged ionic species in solution makes the solution conductive. As ion concentrations increase, conductance of the solution increases. Conductivity is therefore a good measure of the concentration of total dissolved solids and salinity. Conductance is reported as micromhos per centimeter (µmhos/cm). Natural waters can have conductance values as low as 50 µmhos/cm or less and as high as 50,000 µmhos/cm, which is the conductance of seawater (Hem 1989). When levels near the thousands of µmhos/cm, aquatic animals will start to be harmed (Welch *et al.* 1998). Specific conductance can be used as an indicator of changes in cave environments as well.

Solutes

Nitrate (NO_3^-) is the fully oxidized, stable nitrogen compound, and is a form of nitrogen common in aquatic systems. Nitrogen is essential to the survival of all living organisms. Increased nitrate levels can lead to an increase in plant and algal growth in watersheds. The California Code of Regulations states that the primary maximum contaminant level for drinking water is 45 mg/L (http://ccr.oal.ca.gov).

Chloride (Cl^-) is the only form of chlorine that is of major significance in water exposed to the atmosphere (Hem 1989). Chlorides are salt compounds that mostly originate from the weathering of rocks, but inputs of sea salts and pollution can be locally important (Allan 1995). Chlorides can contaminate freshwater streams and lakes and aquatic communities and fish cannot survive high levels of chloride. Chloride concentrations can be used to monitor changes in cave environments as well.

Fecal coliforms

Total coliform bacteria count is a standard test for the bacteriologic quality of waters. Fecal coliforms are a type of bacteria that live in the digestive tract of warm-blooded animals and are excreted in the feces. Coliform bacteria are not harmful themselves, but are indicators of other harmful bacteria. Elevated coliform counts are often a result of an increase in sewage or agricultural waste into an aquatic system, which can lead to a decrease in dissolved oxygen levels and harm aquatic organisms. The United States Environmental Protection Agency (EPA) states that fecal coliforms in fresh waters used for primary contact (including such activities as swimming, rafting and kayaking) in the north coastal region of California should not exceed bacterial densities of 50 per 100 ml of water (www.epa.gov/ost/beaches/local/sum2.html). The EPA also states that total coliforms in drinking water must not exceed 0 mg/L (www.epa.gov/safewater/mcl.html).

The complete sets of water quality data from the 2005 sampling season are presented in the attached appendices. Samples were analyzed for different constituents depending on the site. In the following text and charts, we report only the laboratory results of the water quality analyses, with the exception of dissolved oxygen. Dissolved oxygen was only measured in the field, with the YSI Sonde. In most cases, two to three replicate measurements were made, and the means of the replicate measurements are plotted in the following charts. The number of replicate measurements of a given parameter for a given site is listed on each chart.

LABE:

Concentrations of alkalinity expressed as $CaCO_3$ and HCO_3^- for melted ice and water samples collected at LABE ranged from a low of not detected (ND) for a water sample at Incline Cave to a high of 180 mg/L for $CaCO_3$ and 220 mg/L for HCO_3^- from a water sample collected at Duffy's Well. Alkalinity was measured in both May and October at three sites. Mean $CaCO_3$ was higher in October in two of the three sites (Figure 2). Mean HCO_3^- was higher at all three sites in October (Figure 3).

Specific conductance measurements ranged from a low of ND for a water sample collected at Incline Cave to a high of 589 µmhos/cm for a water sample collected at Duffy's Well. Specific conductance was measured in both May and October at four sites, and was equal to or greater in October than May at these four sites (Figure 4).

pH measurements ranged from a low of 5.26 from a water sample collected at Incline Cave to 9.68 for a water sample collected at Big Painted Cave. With the exception of Blue Glacier Cave (pH = 5.6) all samples measured from other sites at LABE were in the range of 6-9, considered acceptable for most aquatic life. Mean pH was slightly lower in October than May at all four sites measured both months (Figure 5).

Dissolved oxygen measurements at all sites were taken in situ with a YSI Sonde. Dissolved oxygen concentrations were only available for a limited number of sites in October and ranged from a low of 3.33 mg/L (below the 5 mg/L minimum for cold water aquatic life) for a water sample collected at Duffy's Well to a high of 12.36 mg/L for a water sample collected at Merrill Ice Cave.

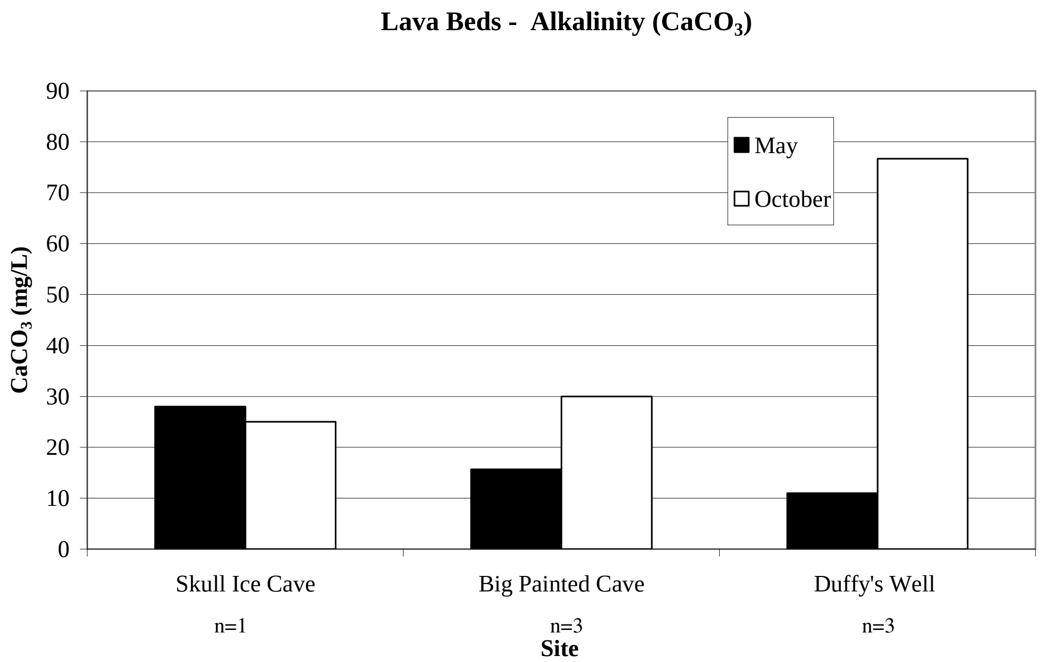

Figure 2. Alkalinity measured as $CaCO_3$ of water samples taken from selected sites at Lava Beds National Monument in 2005.

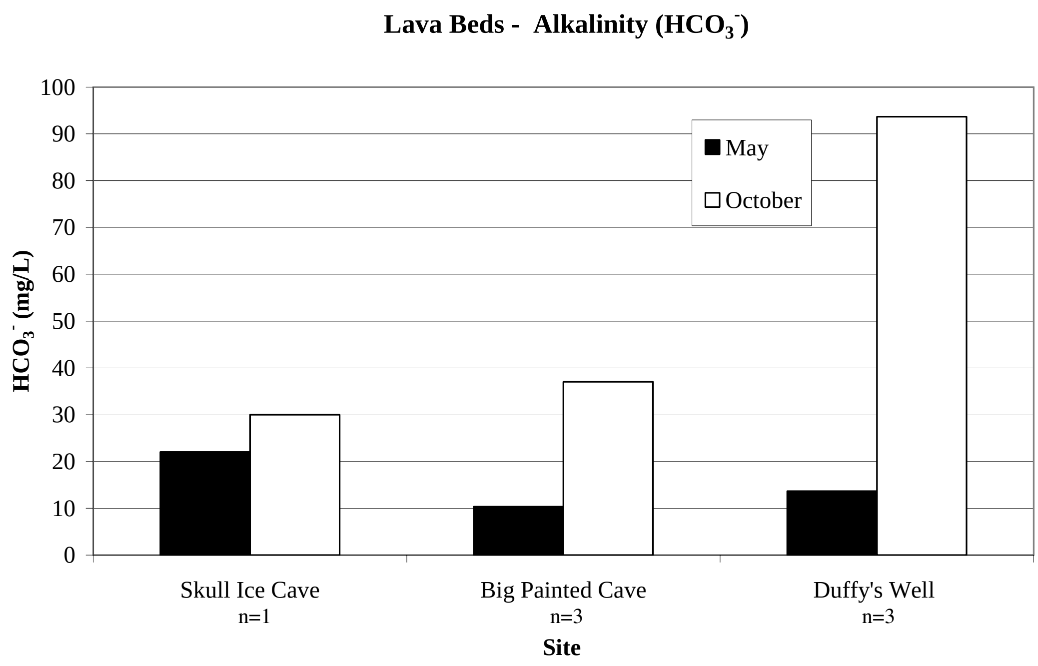

Figure 3. Alkalinity measured as HCO_3^- of water samples taken from selected sites at Lava Beds National Monument in 2005.

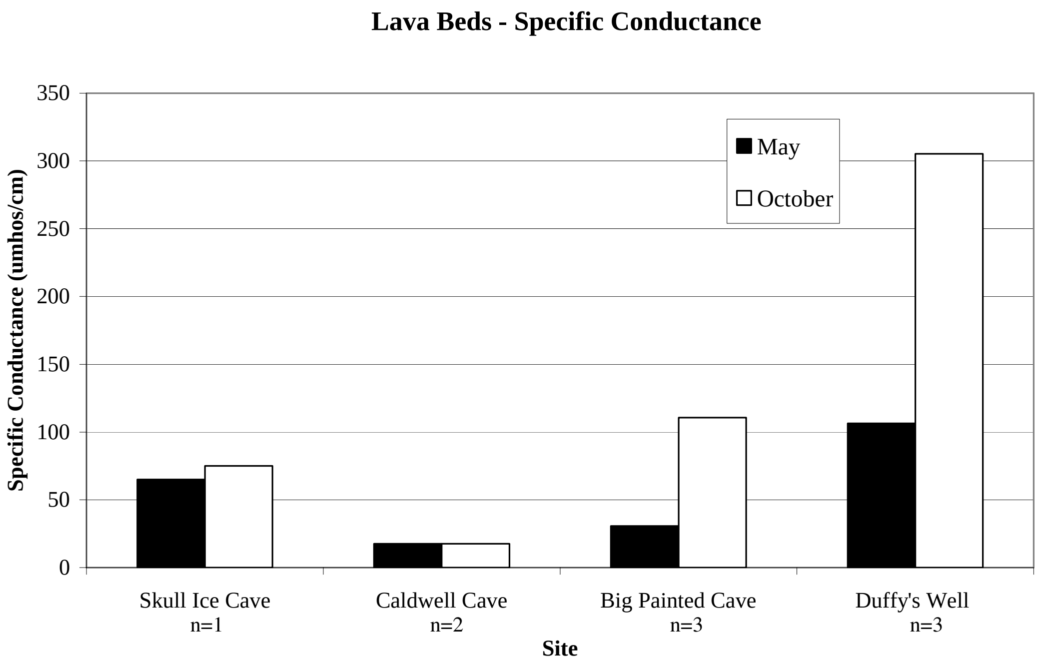

Figure 4. Specific conductance of water samples taken from selected sites at Lava Beds National Monument in 2005.

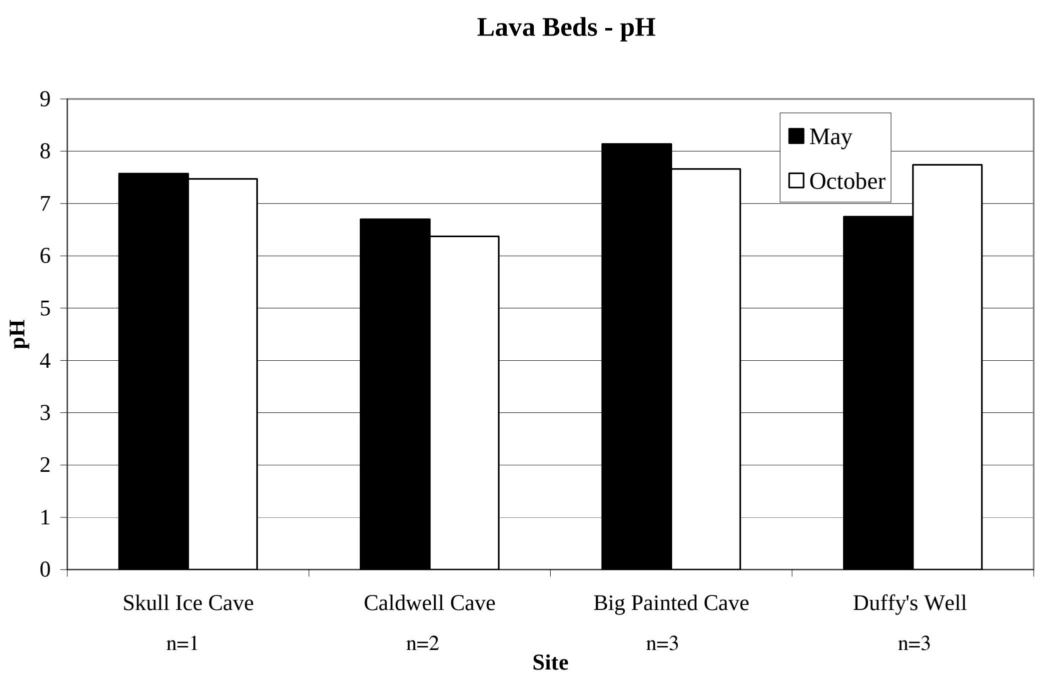

Figure 5. pH of water samples taken from selected sites at Lava Beds National Monument in 2005.

LAVO:

Concentrations of alkalinity expressed as $CaCO_3$ and HCO_3^- for water samples collected at LAVO ranged from a low of ND for samples collected at Terrace Lake, Shadow Lake and Sifford Lake #1 to a high of 66 mg/L for $CaCO_3$ and 81 mg/L for HCO_3^- for samples collected at Hat Creek. $CaCO_3$ was higher in August than June in six of the eight sites sampled in both months and higher in August than July in four of the six sites sampled in both months (Figures 6a. and 6b.). (Sites were sampled the last week of August and the first day of September, but are referred to as the August sampling period in this report). HCO_3^- was higher in August than June in six of the eight sites sampled both months and higher in August than July in four of the six sites in both months (Figures 7a. and 7b.).

Specific conductance measurements ranged from a low of ND for water samples taken at Lake Helen, Terrace Lake, Shadow Lake, Sifford Lake #1, Sifford Lake #2, Feather Lake and Upper Twin Lake to a high of 97 µmhos/cm for a site measured in Ridge Lake. Specific conductance was slightly higher in July than August in three of the five sites sampled in both months (Figure 8).

pH measurements ranged from a low of 5.88 for a water sample collected at Terrace Lake to a high of 9.62 for a water sample collected at Manzanita Lake. The only other site with a pH outside of the acceptable limits for most aquatic life was Summit Lake (pH = 5.9). pH was higher in August than June in all eight sites sampled both months and higher in August than July in six of the seven sites sample both months (Figures 9a. and 9b.).

Dissolved oxygen (DO) measurements ranged from a low of 6.1 mg/L from a water sample collected in situ at Sifford Lake #2 to a high of 12.34 mg/L for a water sample collected in situ at Manzanita Lake. DO was higher in June than in August at all sites sampled both months and higher in July than August at five of the seven sites sampled both months (Figures 10a. and 10b.).

Fecal and total coliform colonies were counted for water samples collected from 13 lakes. Total coliform includes benign, naturally occurring bacteria as well as fecal bacteria, which can cause disease in humans. Fecal coliform colonies ranged from a low of <2 colonies at Butte Lake, Manzanita Lake, Summit Lake, Horseshoe Lake, Crystal Lake, Juniper Lake, Emerald Lake, Lake Helen, Crumbaugh Lake, Terrace Lake, Snag Lake, Upper Twin Lake and Lower Twin Lake to a high of 13 colonies at Snag Lake, which is within the safe limits for recreational use. Total coliform colonies ranged from a low of <2 colonies at Lake Helen, Crumbaugh Lake, Horseshoe Lake, Upper Twin Lake and Butte Lake to a high of 140 colonies at Snag Lake. Total coliform counts were higher in August than June at all three sites sampled both months and higher in July than August in three of the four sites sampled both months (Figures 11a. and 11b.).

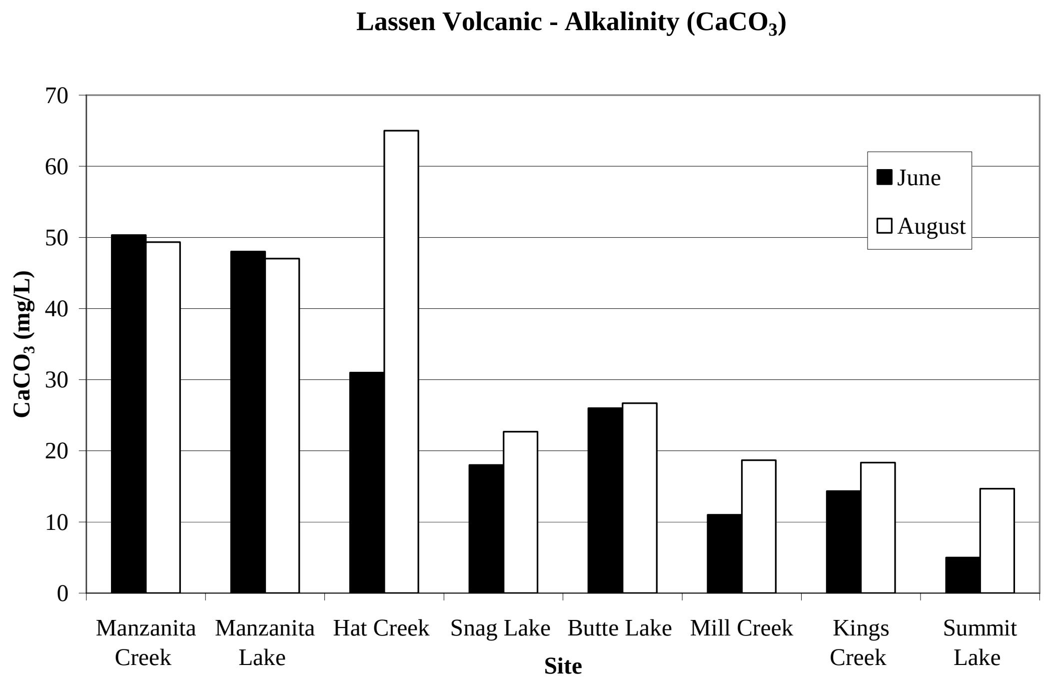

Figure 6a. Alkalinity measured as $CaCO_3$ of water samples taken from selected sites at Lassen Volcanic National Park in 2005 (n=3).

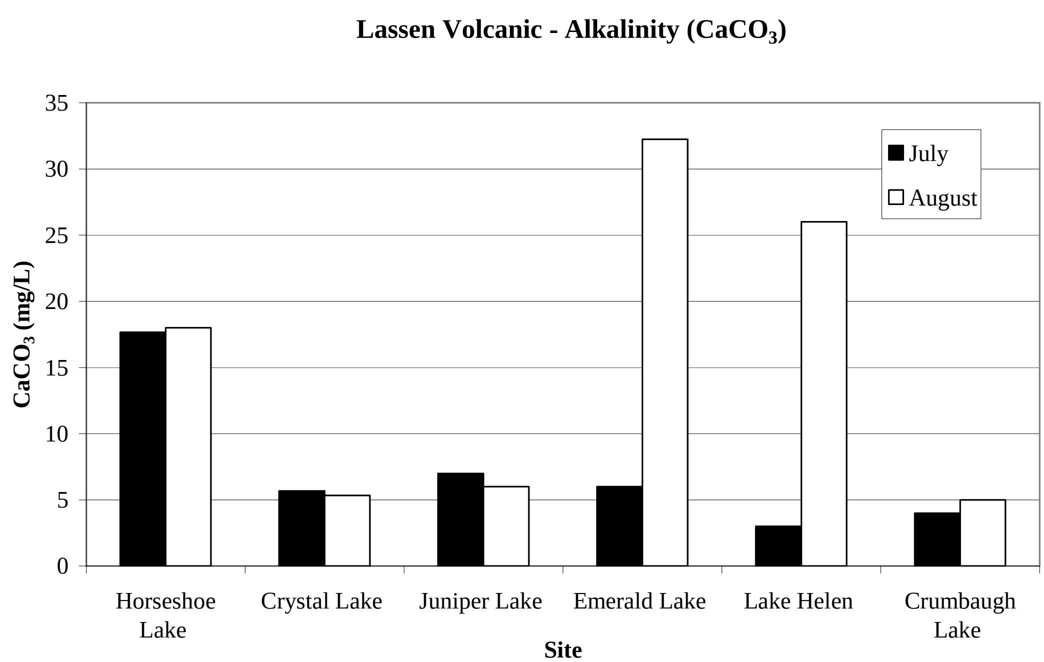

Figure 6b. Alkalinity measured as $CaCO_3$ of water samples taken from selected sites at Lassen Volcanic National Park in 2005 (n=3).

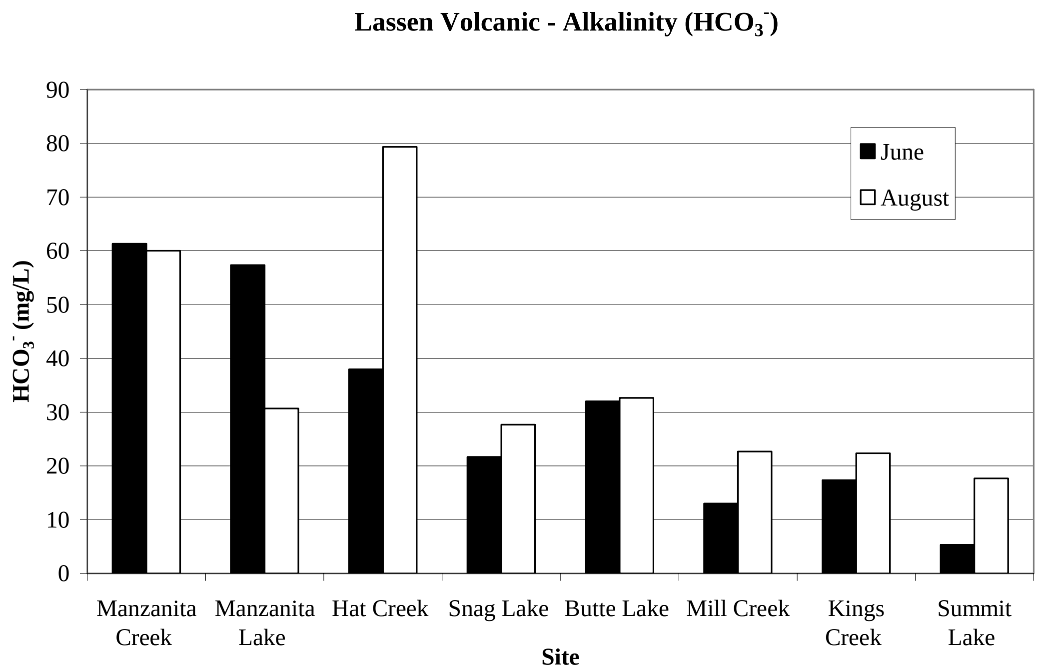

Figure 7a. Alkalinity measured as HCO_3^- of water samples taken from selected sites at Lassen Volcanic National Park in 2005 (n=3).

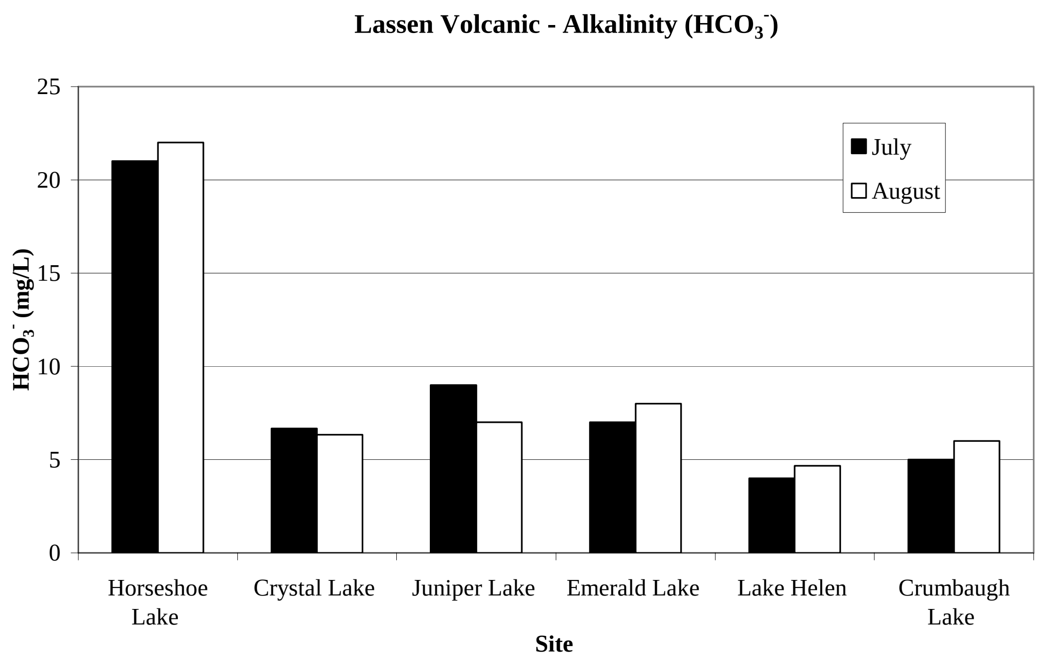

Figure 7b. Alkalinity measured as HCO_3^- of water samples taken from selected sites at Lassen Volcanic National Park in 2005 (n=3).

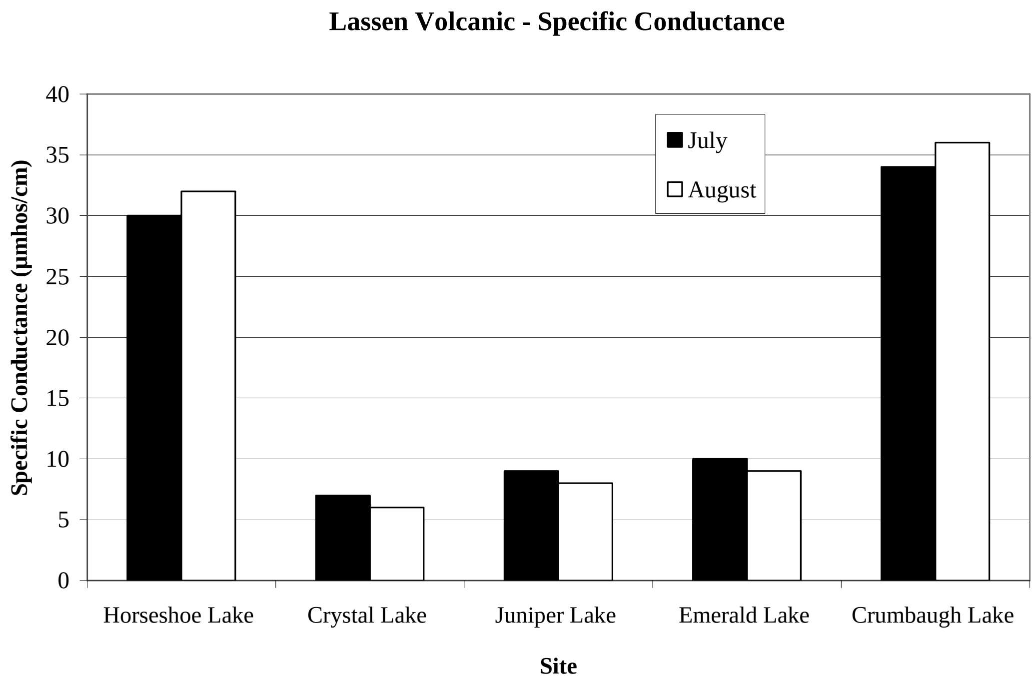

Figure 8. Specific conductance of water samples taken from selected sites at Lassen Volcanic National Park in 2005 (n=1).

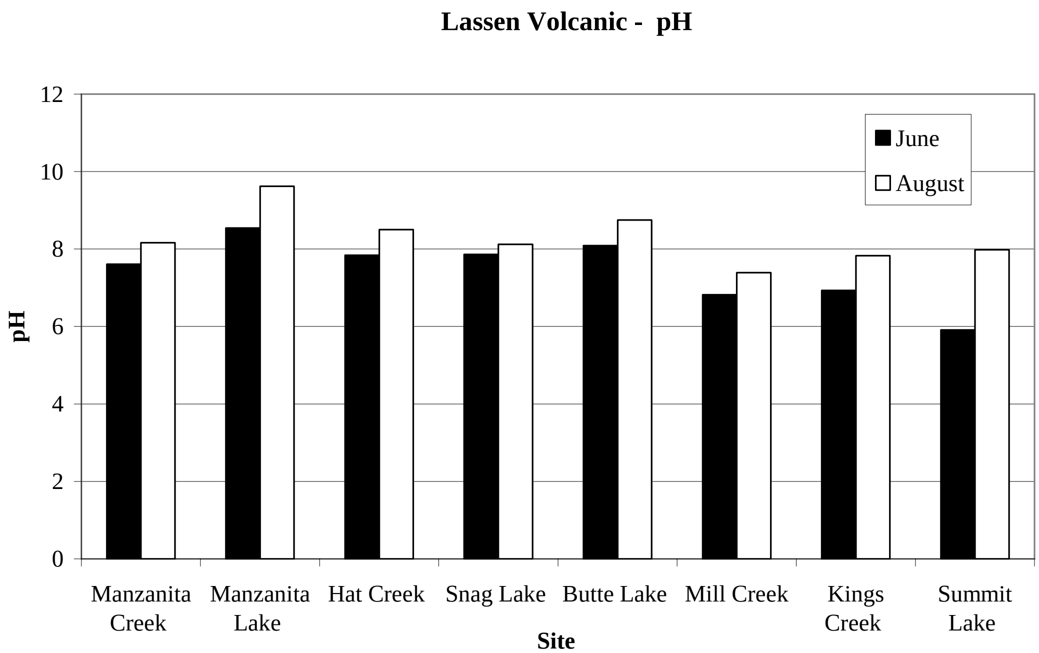

Figure 9a. pH of water samples taken from selected sites at Lassen Volcanic National Park in 2005; for all June samples n=3 and for all August samples n=1.

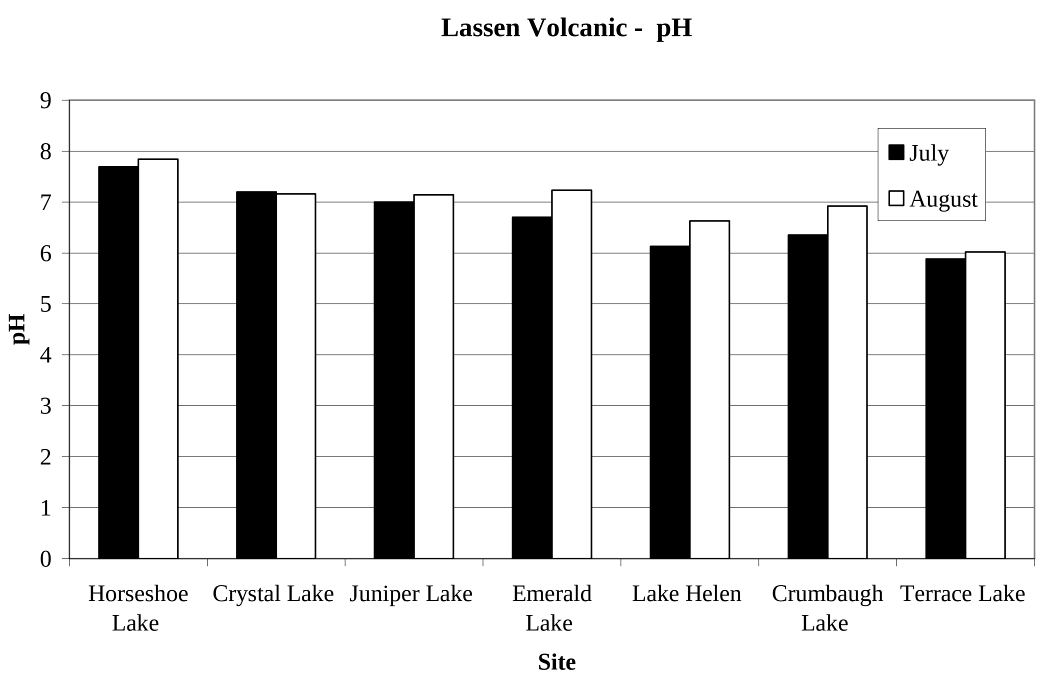

Figure 9b. pH of water samples taken from selected sites of Lassen Volcanic National Park in 2005 (n=1).

Lassen Volcanic-Dissolved Oxygen Content

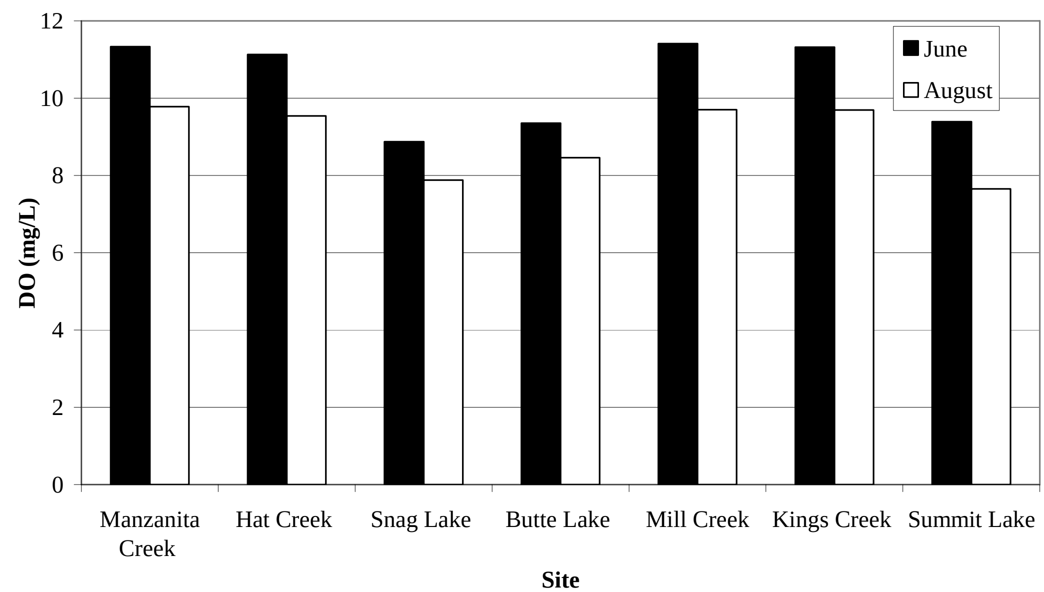

Figure 10a. Dissolved oxygen content of water samples taken from selected sites at Lassen Volcanic National Park in 2005 (n=3).

Lassen Volcanic - Dissolved Oxygen Content

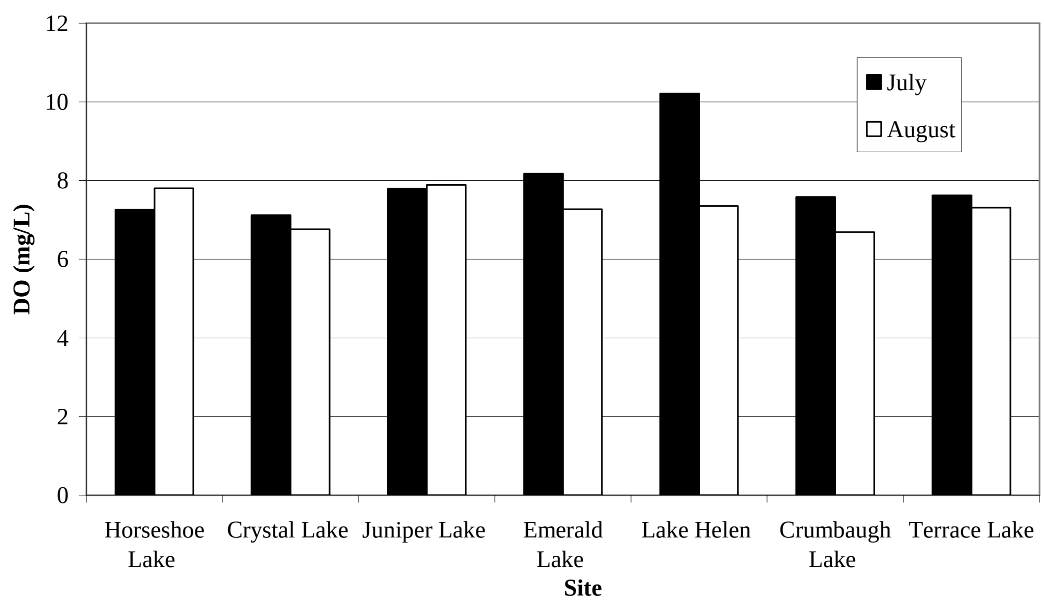

Figure 10b. Dissolved oxygen content of water samples taken from selected sites at Lassen Volcanic National Park in 2005 (n=3).

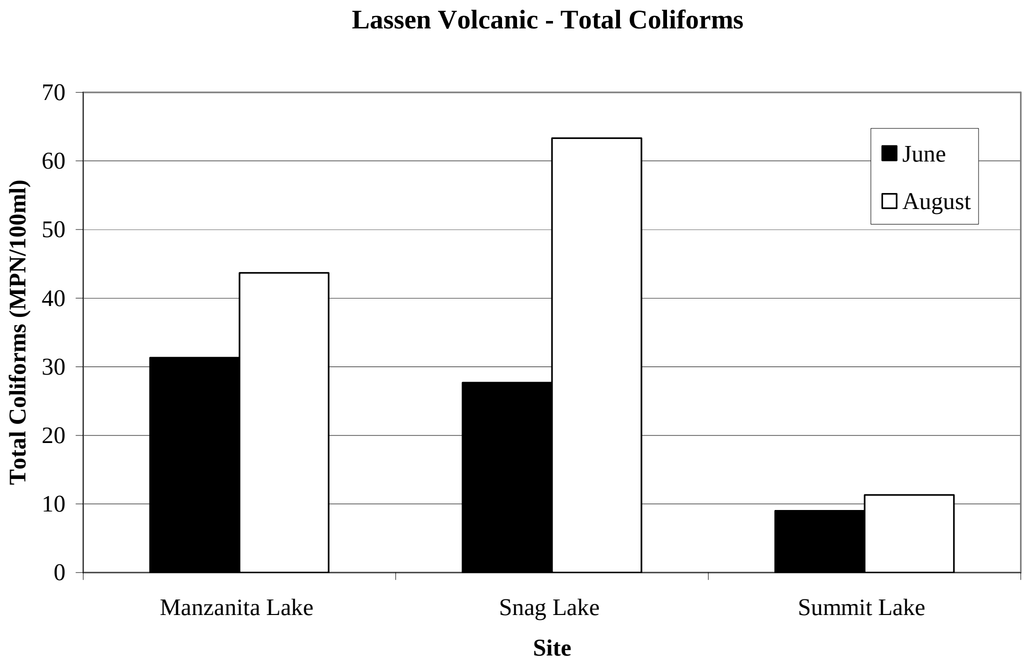

Figure 11a. Most probable number of total coliforms/100 ml of water samples taken from selected sites at Lassen Volcanic National Park in 2005 (n=3).

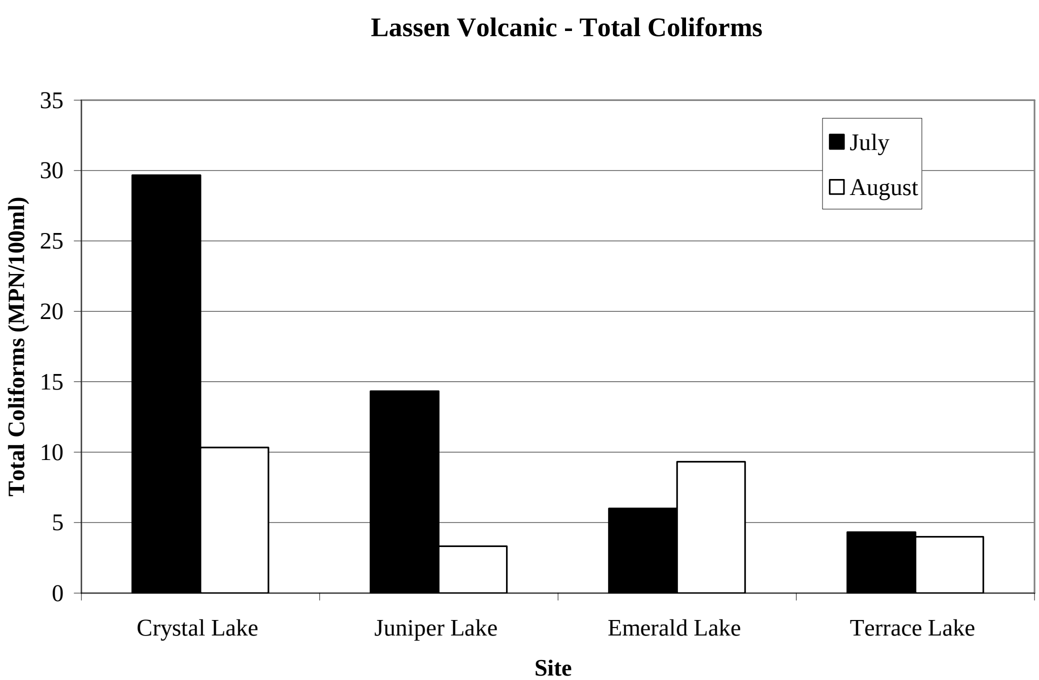

Figure 11b. Most probable number of total coliforms/100ml of water samples taken from selected sites at Lassen Volcanic National Park in 2005 (n=3).

ORCA:

Concentrations of alkalinity expressed as $CaCO_3$ for water samples collected at ORCA ranged from a low of 30 mg/L for a sample collected at Lake Creek at culvert to a high of 120 mg/L for samples collected from Lower Cave Creek at bridge, Lower Cave Creek at entrance, Lower Cave Creek at culvert and Marble Springs. Mean $CaCO_3$ was equal to or greater in samples taken in October than May at all seven sites measured both months (Figure 12). HCO_3^- measurements were only available in October and ranged from a low of 48 mg/L at Lake Creek at culvert to a high of 120 mg/L at Lower Cave Creek at entrance, Lower Cave Creek at bridge, Lower Cave Creek at culvert and Marble Springs.

Specific conductance measurements were only available in May and ranged from a low of 34 μmhos/cm for a sample collected at Lake Creek at culvert to a high of 220 μmhos/cm for a sample collected at the Cave Pool at Washington Monument. pH measurements ranged from a low of 7.3 at the Lake Creek at culvert site to a high of 8.1 at Marble Springs. Mean pH was equal to or greater in samples taken in October than May at five of the seven sites measured both months (Figure 13).

Dissolved oxygen concentrations ranged from a low of 10.48 mg/L for a water sample collected in situ at Cave Pool at Washington to a high of 11.87 mg/L for a water sample collected in situ at Marble Springs. Mean DO concentrations were lower in October than May in all six sites measured in both months (Figure 14).

Chloride concentrations ranged from a low of 0.61 mg/L at Lake Creek at culvert to a high of 1.5 mg/L at Lower Cave Creek at bridge and were higher in October than May at all three sites measured both months (Figure 15). Nitrate concentrations ranged from ND at Lower Cave Creek at culvert, Lower Cave Creek at bridge and Lake Creek at culvert to 0.11 mg/L at Lower Cave Creek at bridge.

Fecal coliform colonies ranged from <2 colonies from a sample taken at Lower Cave Creek at entrance to 8 colonies from a sample taken at Lower Cave Creek at bridge. Total coliform colonies ranged from <2 colonies from a sample taken at Lower Cave Creek at entrance to 27 colonies at Lower Cave Creek at bridge.

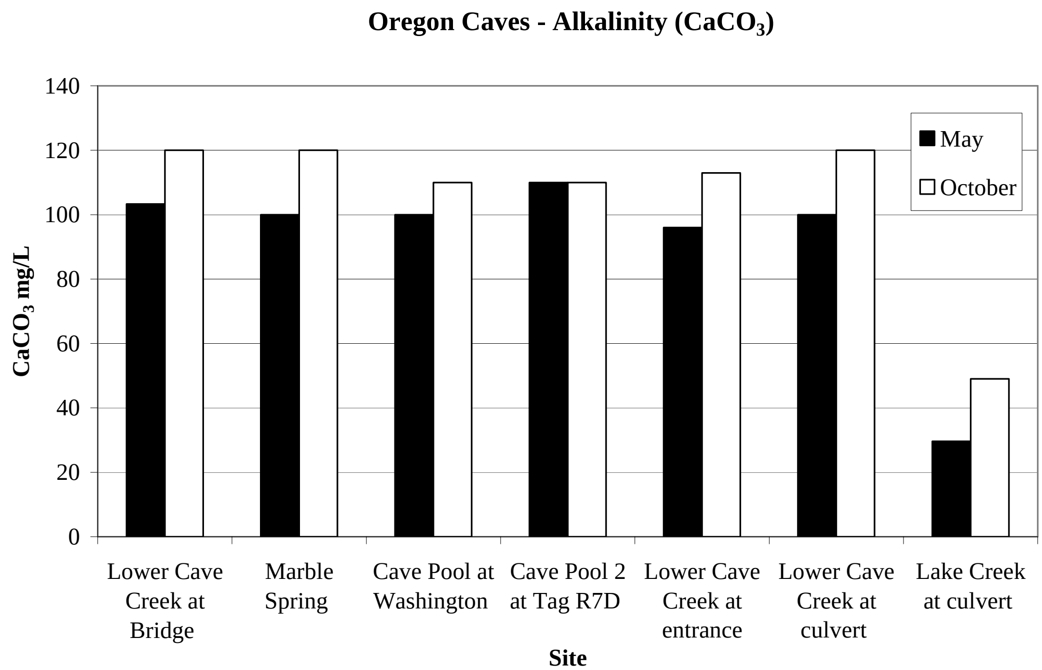

Figure 12. Alkalinity measured as $CaCO_3$ of water samples taken from selected sites at Oregon Caves National Monument in 2005 (n=3).

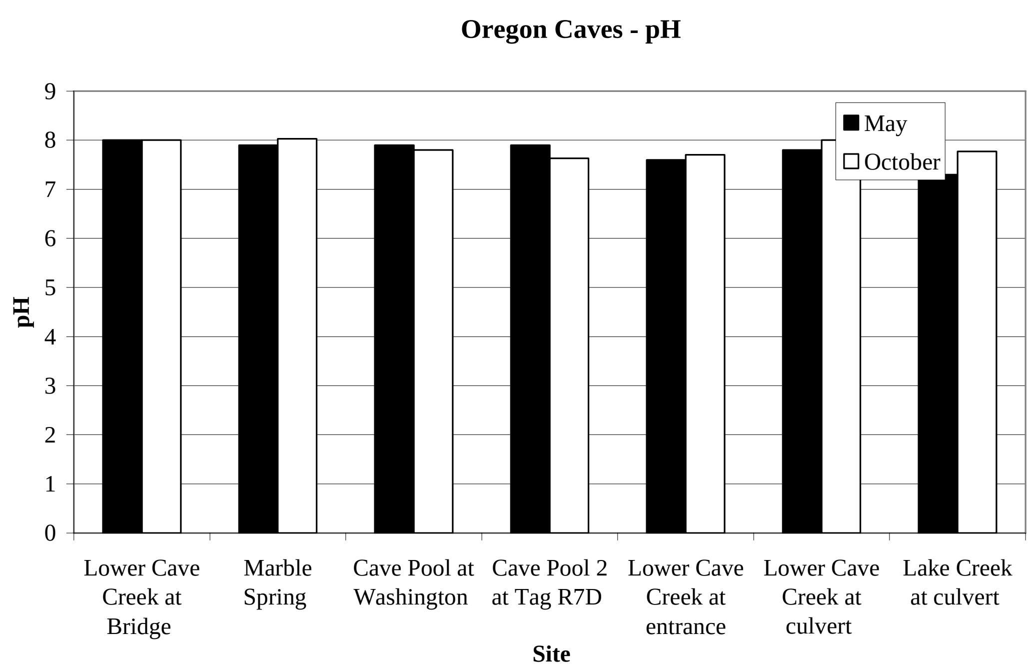

Figure 13. pH of water samples taken from selected sites at Oregon Caves National Monument in 2005; for all May samples n=1 and for all October samples n=3.

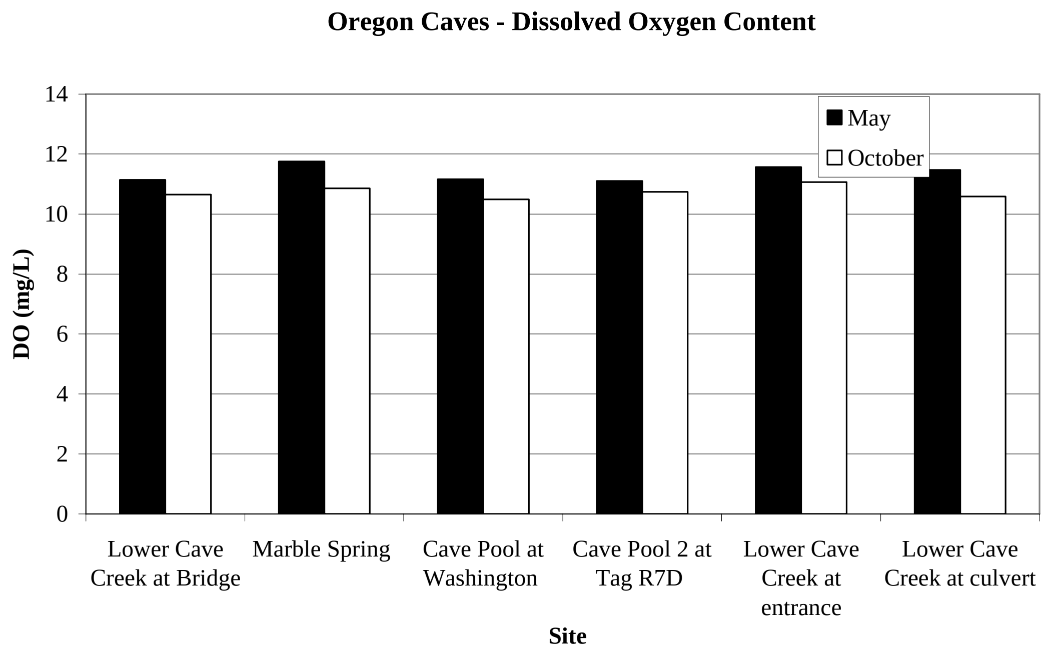

Figure 14. Dissolved oxygen content of water samples taken from selected sites at Oregon Caves National Monument in 2005 (n=3).

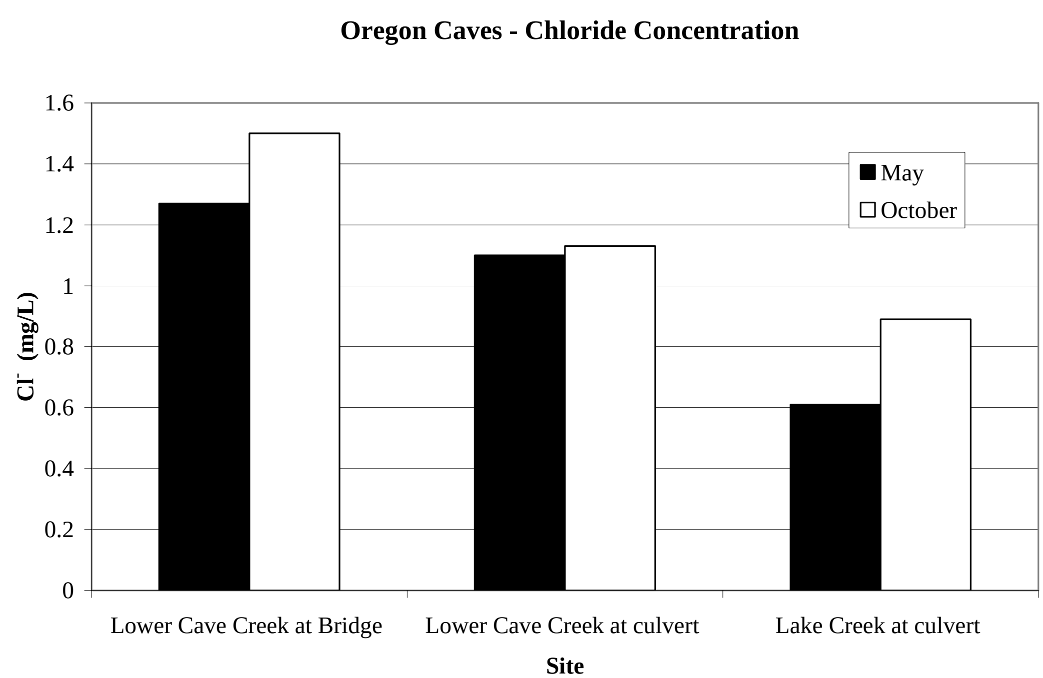

Figure 15. Chloride concentration of water samples taken from selected sites at Oregon Caves National Monument in 2005 (n=3).

Summary

This report presents the results of water sampling conducted from May through September, 2005 at Lava Beds National Monument, Lassen Volcanic National Park, and Oregon Caves National Monument. These samples represent a limited monitoring program designed to provide baseline data and to guide future monitoring efforts. No specific hypothesis was being tested in this effort. More intensive and extensive water quality sampling would be necessary to define diurnal, seasonal, and inter-annual trends, variability for a given water quality parameter or constituent, and variation of water quality measurements across the landscape of the park units. The upcoming National Park Service Klamath Network Water Quality Phase III will address specific monitoring needs and protocols in the park units in more detail.

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Appendices

For complete results, see the following Excel data tables in the attached CD:

a. LABE LAVO ORCA 2005 WQ field data
b. LABE May 2005 1
c. LABE May 2005 2 ions
d. LABE Oct 2005
e. LAVO June 2005 1
f. LAVO June 2005 2
g. LAVO July 2005 1
h. LAVO July 2005 2
i. LAVO July 2005 3
j. LAVO August 2005 1
k. LAVO August 2005 2
l. LAVO August 2005 3
m. LAVO September 2005
n. ORCA May 2005 1
o. ORCA May 2005 2
p. ORCA October 2005 1
q. ORCA October 2005 2